The Meteorological Magazine

July 1990

Forecasting the storm of 8 November 1989
UK/WMO Voluntary Co-operation Programme
The summer of 1989

992 Vol. 119 No. 1416

The
Meteorological
Magazine

July 1990
Vol. 119 No. 1416

551.509.313:551.509.5:551.515.1(420)

Forecasting the storm of 8 November 1989 — a success for the man-machine mix

A. Woodroffe
Meteorological Office, Bracknell

Summary

A description is given of the beneficial influence of forecasters' expertise in modifying guidance provided by the Meteorological Office's numerical weather prediction models for a storm over southern England on 8 November 1989.

1. Introduction

The Meteorological Office produces numerical weather predictions using two forecast models — a global coarse-mesh model with a horizontal grid spacing of about 150 km, and a fine-mesh model covering the North Atlantic and north-west Europe with a 75 km grid spacing. Both models use 15 levels in the vertical.

Most forecasters have developed considerable respect for the overall quality of the guidance provided by these models. In the case of short-period forecasts up to 36 hours, it is relatively rare these days for the models to get the evolution totally wrong; the forecaster is mainly concerned with fine-tuning the guidance and interpreting it to meet customer needs. The models have proved particularly good at handling major cyclogenetic events, resulting in a significant improvement in the accuracy and timeliness of gale warnings from the Central Forecasting Office (CFO) over the last decade.

Despite these advances, there have been some notable failures, in particular the case of the so-called 'Great Storm' of 15–16 October 1987 (Woodroffe 1988, Gadd and Morris 1988). It is important, therefore, that the forecaster should not become complacent when assessing the model output. Another example of poor model guidance occurred more recently on 8 November 1989 in a situation which, though much less severe, presented certain forecasting problems resembling those associated with the Great Storm. On this occasion, the forecasters in CFO made important changes to the model output, thereby effecting a significant improvement in the quality of the guidance. The main purpose of this paper is to discuss the reasoning behind those changes, since some of the factors may serve as a warning signal to forecasters in similar situations in the future.

2. Synoptic developments

On 8 November 1989 a vigorous depression moved north-eastwards over southern Britain, bringing a broad band of moderate/heavy rain across England and Wales and very strong winds in its circulation. Many stations in southern England and East Anglia reported gusts exceeding 50 kn, with 75 kn being recorded at Portland Bill and 60 kn at London Weather Centre (at the time the highest wind speed recorded in London since the Great Storm). The development of the depression (labelled Low 'U') is portrayed in Fig. 1 which shows the CFO mean-sea-level pressure (MSLP) and the 500 mb height analyses at 12-hourly intervals, commencing at 0000 UTC on 7 November 1989. At that initial time the low was just a shallow wave over the central North Atlantic near 42° N, 34° W (though due to a lack of ship data, its exact position and depth were both uncertain). During the next 36 hours the centre deepened substantially as it moved east-north-eastwards ahead of the sharpening upper trough.

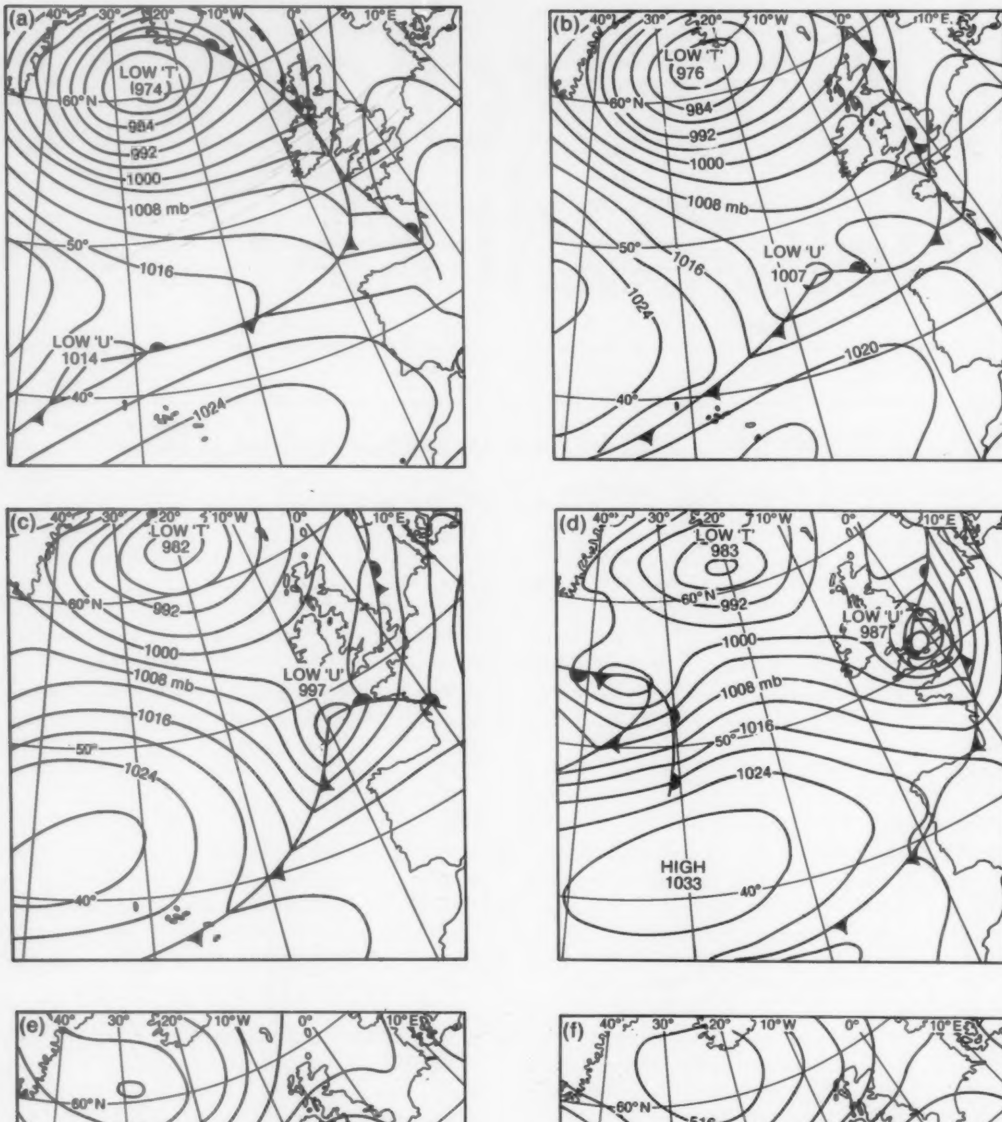

Figure 1. MSL pressure analyses for (a) 0000 UTC on 7 November 1989, (b) 1200 UTC on 7 November 1989, (c) 0000 UTC on 8 November 1989 and (d) 1200 UTC on 8 November 1989. (e) to (h) are 500 mb analyses (heights in dam) for the same times as (a) to (d).

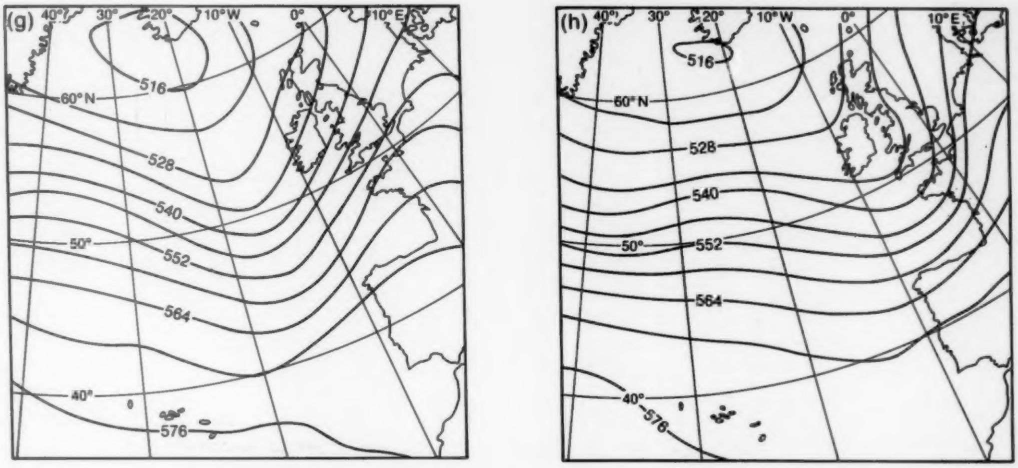

Figure 1. Continued.

The track of the low and its central pressure are plotted in Fig. 2. Although the rate of deepening appears rather erratic, this is likely to be a reflection of the uncertainty in the analysed depth at various stages. The steady curving of the track to the left in the latter stages of deepening was a critical factor in determining the extent of the strong winds over southern Britain. However, at no time was the rate of deepening exceptional, the largest pressure falls being of the order of 8–9 mb per 3 hours over south-west England on the morning of the 8th. As so often happens, the very strong winds were mainly a consequence of the marked pressure rises which developed behind the centre, in association with the confluent forward portion of the upper trough.

An additional complication underlying the analysis was the suggestion of a complex structure with a shallow wave running ahead of the main centre. For example, the analysis for 0600 UTC on 7 November 1989 (not shown) indicated two distinct waves based on ship observations and CFO's interpretation of the satellite imagery. Detailed analysis of observations to the south of Ireland on the evening of 7 November also revealed signs of a forward centre. Whilst any such double structure was of relatively little significance for the weather over the United Kingdom, it may have had an impact on the performance of the model, as will be discussed later.

3. Medium-range forecasts

Medium-range guidance from both the coarse-mesh model and from the numerical model run by the European Centre for Medium-range Weather Forecasts (ECMWF) generally failed to capture the vigorous nature of the development, as is evident from the MSLP forecasts reproduced in Fig. 3. These charts are all valid at 1200 UTC on 8 November 1989 (when the low was an active feature of 984 mb centred just north-west of

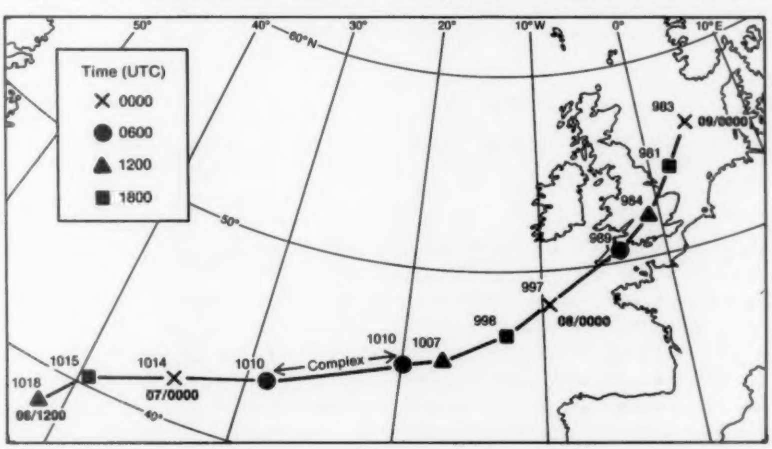

Figure 2. Track and central pressure (mb) of the low from 1200 UTC on 6 November to 0000 UTC on 9 November 1989.

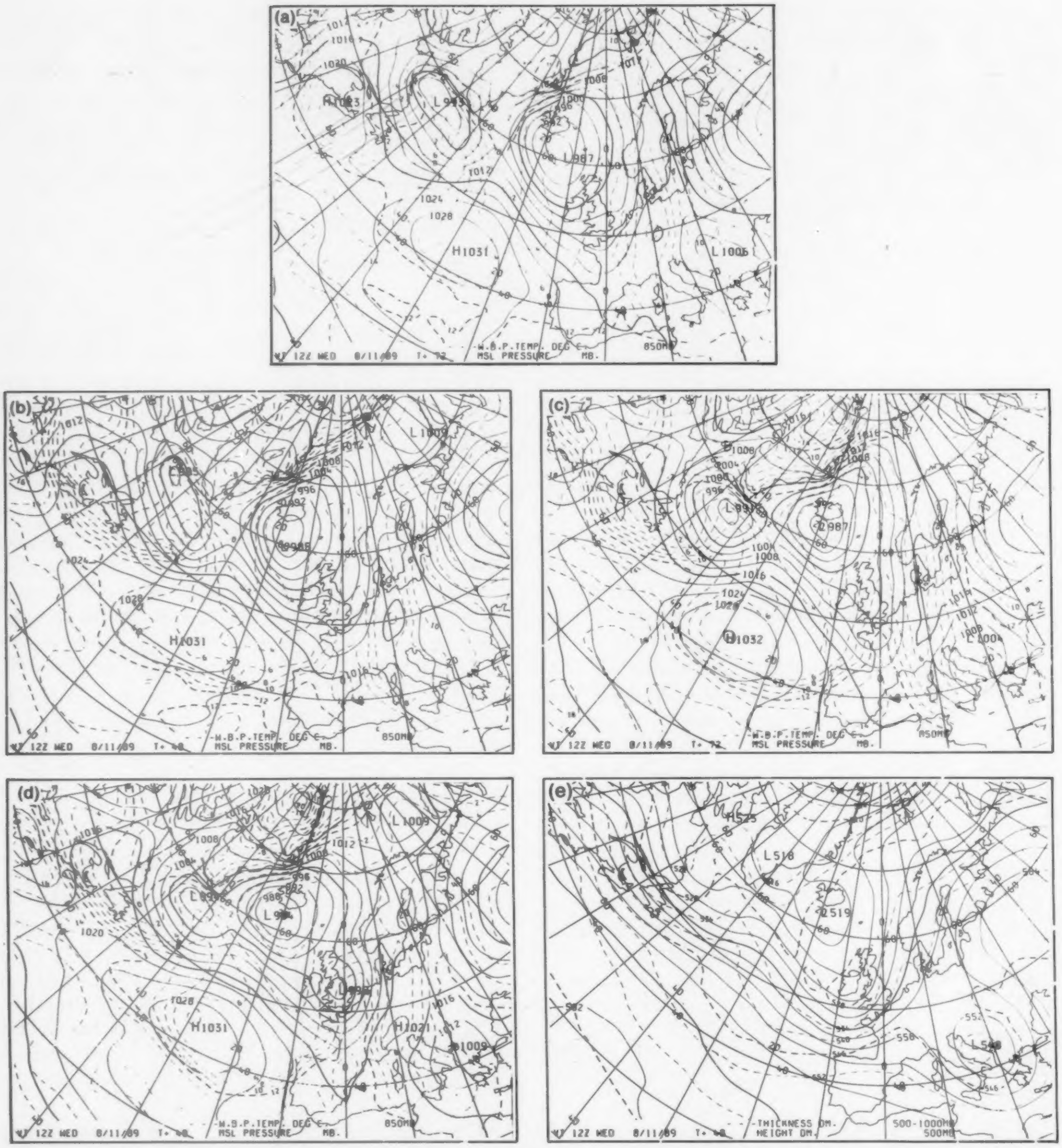

Figure 3. Continuous lines show (a) coarse-mesh 72-hour MSL pressure forecast, (b) coarse-mesh 48-hour MSL pressure forecast, (c) ECMWF 72-hour MSL pressure forecast, (d) ECMWF 48-hour MSL pressure forecast, and (e) coarse-mesh 48-hour 500 mb forecast (heights in dam) all valid for 1200 UTC on 8 November 1989.

London) and typify the guidance received from the models over the preceding days. The 72-hour forecasts from both models produced just a weak trough over the United Kingdom, bearing no resemblance to the features which actually developed.

The 48-hour forecast from the coarse-mesh model (Fig. 3(b)) was almost identical to its 72-hour forecast (Fig. 3(a)); such consistency might normally be expected to bolster confidence in the products. On this occasion the forecasters were far from happy! The featureless nature of the MSLP patterns seemed odd in relation to the substantial troughing generated at 500 mb (Fig. 3(e)), leading to a feeling that there could be much more to this system than the coarse-mesh MSLP fields implied. This suspicion was reinforced by the ECMWF 48-hour MSLP forecast (Fig. 3(d)) which did indicate a more substantial depression over the United Kingdom. Even so, the centre was still too shallow (error $\approx$ 11 mb) and the strength of the gradients significantly under-estimated.

At least some of the differences between the coarse-mesh and ECMWF 48-hour forecasts might be explained by the fact that the ECMWF model started from an analysis with a more pronounced thermal ridge over the incipient wave (the maximum difference in thickness being 3 dam). It is certainly true that the coarse-mesh 48-hour thickness forecast was about 10 dam too low over south-east England, but part of this error was probably a result of the lack of development rather than a cause. Errors in the corresponding ECMWF thickness forecast were generally very small. Further investigations were undertaken to try and determine how critical a factor the initial analysis was; these results are discussed in section 6.

4. Short-range guidance

It was always recognized by the forecasters in CFO that, irrespective of any deficiencies in the analysis, the bland appearance of the medium-range prognoses from the model might be partly attributable to the smoothing effect of the coarse grid. Small-scale or intense systems cannot be resolved properly by this grid and the forecasters had to wait for the short-period fine-mesh forecasts to throw further light on the likely developments.

The fine-mesh run starting from 1200 UTC on 6 November 1989 provided the first reliable indications from the 15-level model of the eventual vigour and track of the low centre. In particular, it will be seen that the 36-hour MSLP forecast (Fig. 4) compares well with the analysis in Fig. 1(c). The 48-hour forecast from the same run (produced for back-up purposes and not generally disseminated) placed the low centre over Hampshire with a reasonably vigorous circulation, and central pressure about 996 mb. It was at this stage that the

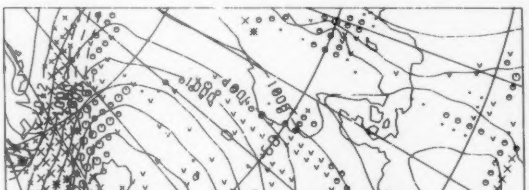

Figure 4. Fine-mesh 36-hour MSL pressure forecast valid for 0000 UTC on 8 November 1989, the various symbols showing areas of precipitation.

first firm warnings were given of the likely developmental nature of the low, the synoptic review issued at 2245 UTC on the 6th indicating that the low was likely to deepen substantially as it engaged the cold air over the Atlantic and that it could turn a little more to the left as a result. Emphasis was also placed on the likelihood of heavy rain, in view of the high dew-points (16 °C) in the warm air.

Following the above comments, the results of the next fine-mesh run based on data for 0000 UTC on 7 November 1989 came as a considerable shock. The model showed a reversion to the weak non-developmental pattern favoured by earlier coarse-mesh runs, as can be seen from the 24- and 36-hour forecasts in Figs 5(a)and 5(b) respectively. At the same time, there appeared to be significant defects in the fine-mesh analysis (even when allowance was made for the uncertainties engendered by a lack of data in the crucial area). In particular, the 1000–500 mb thickness analysis (Fig. 6(a)) failed to show the warm bulge over the wave which one would normally expect with the large well-developed plume of cloud evident on satellite imagery (Fig. 7(a)).

In view of these perceived analysis deficiencies — the forecast sharpening of the upper trough, and previous fine-mesh and ECMWF guidance — it was decided to opt for a much more developmental scenario. The CFO 24-hour MSLP forecast for 0000 UTC on 8 November 1989 (Fig. 5(c)) continued the idea of the wave developing into a vigorous centre as it moved over the south-west approaches, pressure levels being adjusted to be about 12 mb lower than the fine-mesh values (Fig. 5(a)). The corresponding coarse-mesh run started from a rather better analysis of the 1000–500 mb thickness pattern near the wave (Fig. 6) with the help of additional artificial or 'bogus' observations derived from the forecaster's interpretation of the imagery. Although it still failed to develop a discrete centre on its 24-hour forecast (Fig. 5(d)), the marked troughing produced to the south-west of the British Isles encouraged the forecasters, since it was not totally inconsistent with the idea of a deeper centre if allowance was made for the inherent smoothing associated with the coarser grid.

Consideration of the upper-air patterns and satellite imagery provided further support for this cyclogenetic theme. At 0000 UTC on 7 November 1989 the wave was located just ahead of a flat and slightly confluent upper-air trough (Fig. 8) which was also associated with a broad region of strong baroclinicity. Similar patterns have accompanied some notable occasions of marked cyclogenesis (Young 1989), in particular the 'Great Storm' of October 1987 and the 'Burns' Day' storm of 25 January 1990 (McCallum 1990). Satellite imagery (Fig. 7(a)) also showed a region of enhanced convection (C) in the cold air slowly approaching the baroclinic cloud plume, suggesting increasing positive vorticity advection over the wave which could help trigger further development. Later images (Fig. 7(b)) revealed the start

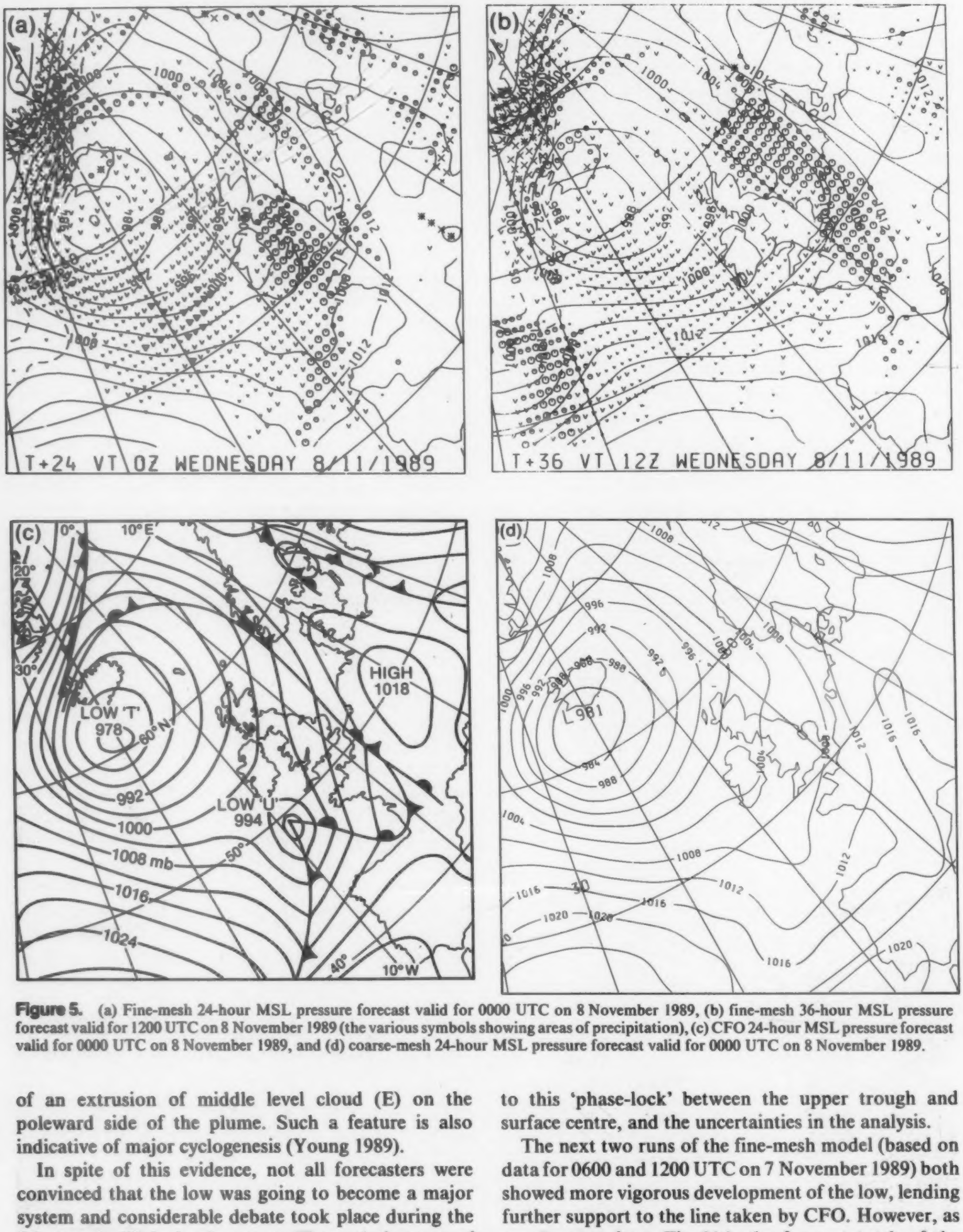

Figure 5. (a) Fine-mesh 24-hour MSL pressure forecast valid for 0000 UTC on 8 November 1989, (b) fine-mesh 36-hour MSL pressure forecast valid for 1200 UTC on 8 November 1989 (the various symbols showing areas of precipitation), (c) CFO 24-hour MSL pressure forecast valid for 0000 UTC on 8 November 1989, and (d) coarse-mesh 24-hour MSL pressure forecast valid for 0000 UTC on 8 November 1989.

of an extrusion of middle level cloud (E) on the poleward side of the plume. Such a feature is also indicative of major cyclogenesis (Young 1989).

In spite of this evidence, not all forecasters were convinced that the low was going to become a major system and considerable debate took place during the 7th over the likely developments. The evolution was, of course, crucially dependent on how well the wave phased in with the amplifying upper trough which had moved eastwards from Canada during the preceding 4–5 days. The variability in the numerical guidance no doubt reflected both the sensitivity of the development to this 'phase-lock' between the upper trough and surface centre, and the uncertainties in the analysis.

The next two runs of the fine-mesh model (based on data for 0600 and 1200 UTC on 7 November 1989) both showed more vigorous development of the low, lending further support to the line taken by CFO. However, as can be seen from Fig. 9(a), the forecast track of the centre lay across the extreme south-east of England, thereby restricting the strong winds to the English Channel and south-east coasts, raising some forecasting problems similar to those associated with the Great Storm.

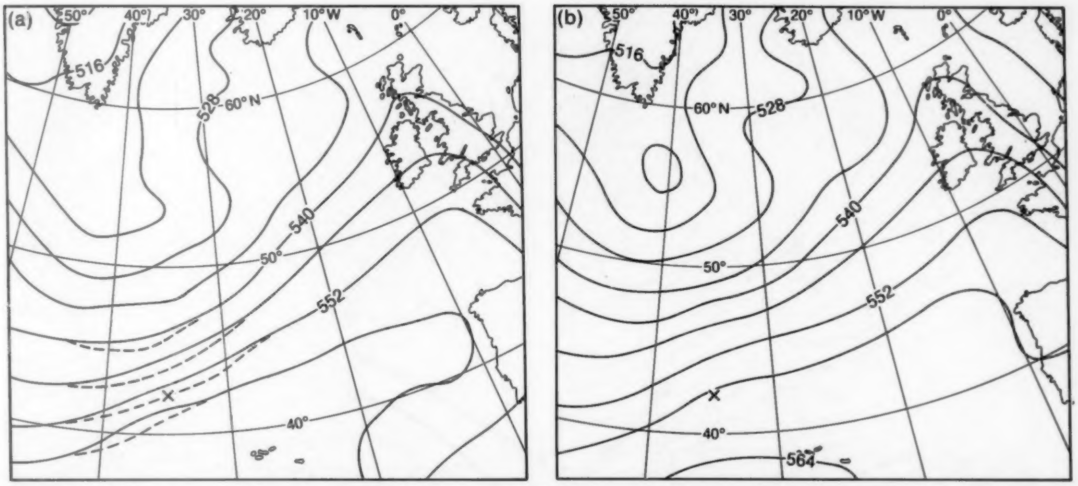

Figure 6. (a) Coarse-mesh thickness (dam) analysis (continuous line) with fine-mesh differences (dashed lines) at 0000 UTC on 7 November 1989, and (b) CFO 1000–500 mb thickness (dam) analysis for 0000 UTC on 7 November 1989. X marks the position of the wave tip.

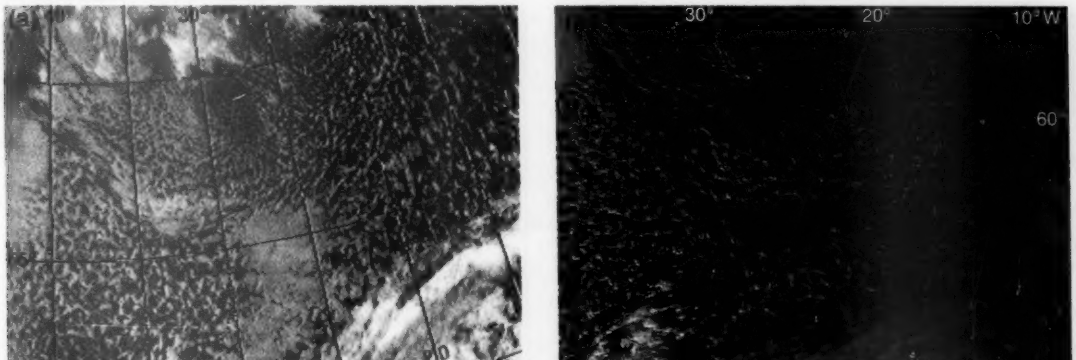

Figure 7. NOAA-11 infra-red images for (a) 0422 UTC and (b) 1359 UTC on 7 November 1989.

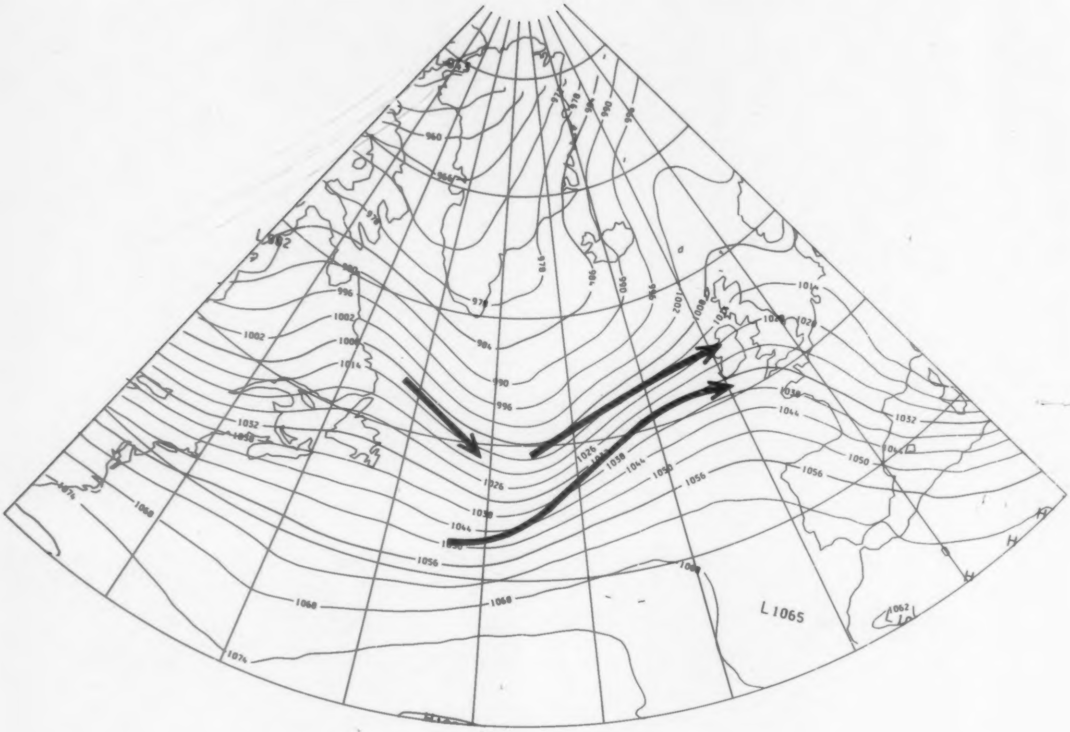

Figure 8. Analysis of the 250 mb surface (heights in dam) for 0000 UTC on 7 November 1989 with solid arrows denoting jet cores.

By that evening, increasing, though still modest, pressure falls over the south-west approaches and reports of gale force winds around the low convinced the CFO forecasters that the anticipated major development was under way. Although the model integrations had started from a good analysis, consideration of the shape and strength of the 1000–500 mb thickness gradients still suggested that the centre would deepen more than indicated and turn on a more northerly track as the thermal pattern became increasingly distorted. The CFO 24-hour MSLP forecast for 1800 UTC on 8 November 1989 (Fig. 9(c)) showed the low about 8 mb deeper than the corresponding fine-mesh product (Fig. 9(b)), whilst tracking the centre across the south-east Midlands to The Wash. Comparison with the analysis in Fig. 9(d) proves that this was excellent guidance, prompting a warning of gales over south-east Britain in the synoptic review issued at 2225 UTC on the 7th, with the possibility of severe gales to the south of the centre as pressure built again behind the confluent upper trough. This theme was followed through the night, specific reference being made in the early morning national radio forecasts of winds up to 60 m.p.h. over southern Britain during the day. Similar early warning was also given of severe gales and later storm-force winds for sea areas in the English Channel and southern North Sea.

5. Fine-mesh forecasts — general aspects

Despite the shortcomings of its MSLP forecasts, the fine-mesh model did give useful general warning of the heavy rain which affected many parts of England and Wales on 8 November. The heaviest rainfall was reported along and to the north of the depression track with totals typically in the range 20–30 mm. However, due to the deficiencies in the forecast depth and track of the depression, the model's rainfall distribution was less satisfactory. For example, the 24-hour forecast in Fig. 9(a) shows the heaviest rain over south-east Britain, whereas the radar display (Fig. 10) indicates that these parts were largely dry at that time, the bulk of the heaviest and most persistent rain being to the north and west of the low centre.

Another feature of the fine-mesh rainfall guidance was that, in general, it spread the rain too quickly north-eastwards across England and Wales. This was particularly noticeable in the run from 0000 UTC on 7 November 1989 which, as discussed earlier, failed to develop a discrete low centre. Despite the deficiencies in the fine-mesh 1000–500 mb thickness analysis referred to in section 4, the initial vertical motion fields (Fig. 11(a)) did show a zone of marked dynamical ascent in the vicinity of the wave. With no significant warm advection diagnosed, this ascent must have been primarily due to positive vorticity advection ahead of the upper-trough

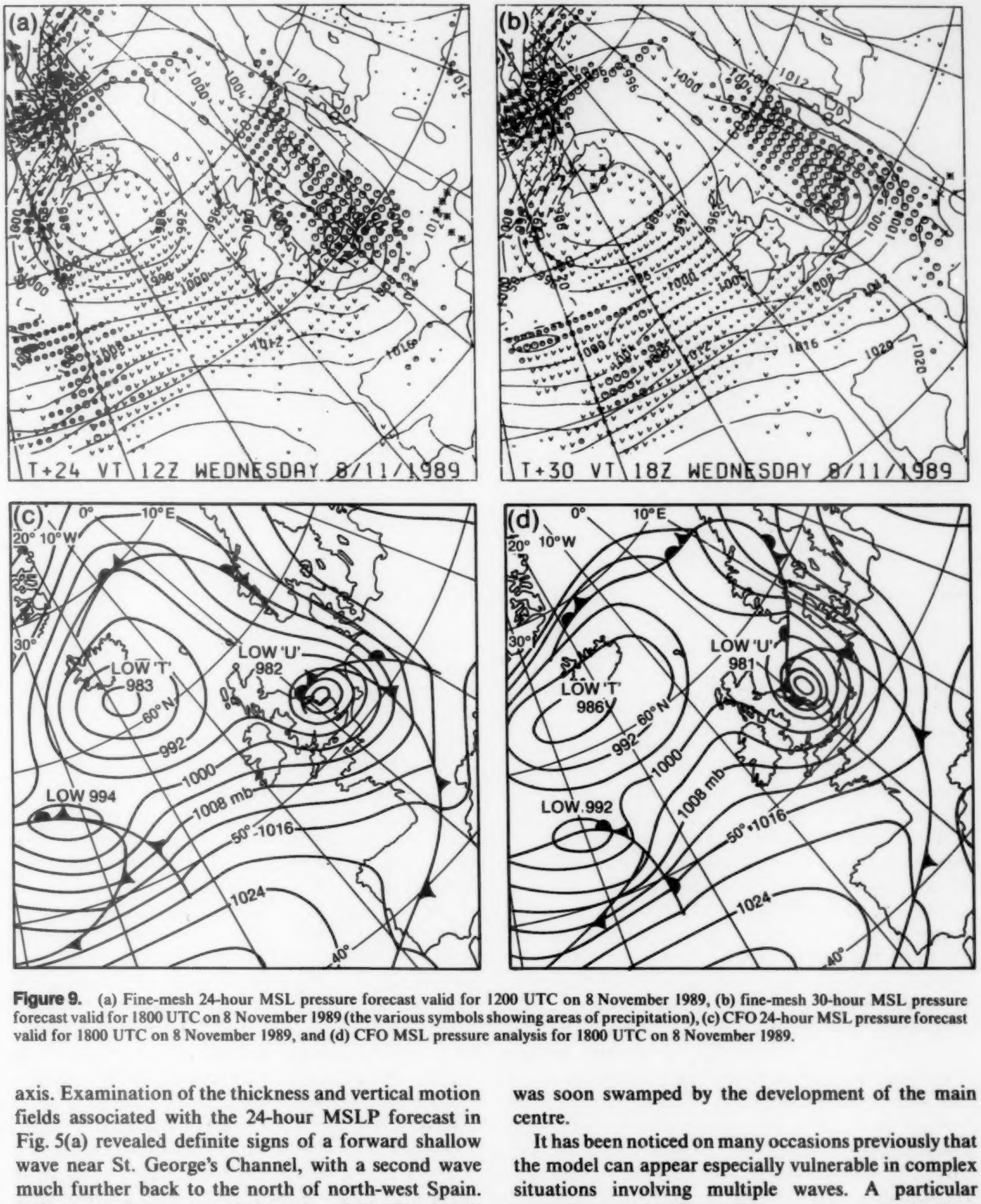

Figure 9. (a) Fine-mesh 24-hour MSL pressure forecast valid for 1200 UTC on 8 November 1989, (b) fine-mesh 30-hour MSL pressure forecast valid for 1800 UTC on 8 November 1989 (the various symbols showing areas of precipitation), (c) CFO 24-hour MSL pressure forecast valid for 1800 UTC on 8 November 1989, and (d) CFO MSL pressure analysis for 1800 UTC on 8 November 1989.

axis. Examination of the thickness and vertical motion fields associated with the 24-hour MSLP forecast in Fig. 5(a) revealed definite signs of a forward shallow wave near St. George's Channel, with a second wave much further back to the north of north-west Spain. Indeed, the forecast vertical motion field (Fig. 11(b)) shows the main area of ascent over and around the United Kingdom at 0000 UTC on 8 November in association with the forward wave and well ahead of the actual position of the low centre at that time. As mentioned earlier, there was some evidence of such a wave to the south of Ireland on the evening of the 7th; however, even if it existed, it was a feeble feature which was soon swamped by the development of the main centre.

It has been noticed on many occasions previously that the model can appear especially vulnerable in complex situations involving multiple waves. A particular example was the Great Storm where several minor centres are known to have run across the Bay of Biscay before the arrival of the final low which developed into the major storm. In such cases, the potential for development of each individual wave will clearly depend on the precise details of the atmospheric structure. The net effect, as was observed in the case of the Great Storm (Lorenc *et al.* 1988), may be to make the results of the

numerical integrations very sensitive to relatively minor deficiencies in the analysis. In particular, it can be crucial whether the model has properly resolved the details of both the surface and upper-air patterns in the vicinity of the rearward low centre, which is often located in the main cyclonic development area just ahead of the upper-trough axis.

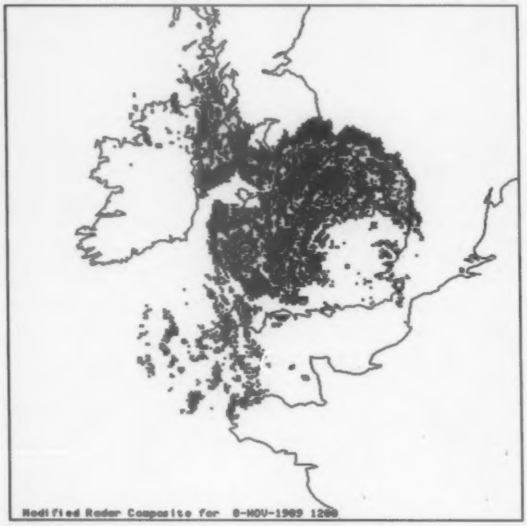

Figure 10. Rainfall radar display at 1200 UTC on 8 November 1989. Colours indicate rainfall rates in ascending order from green, through yellow, red, pink, dark blue and light blue to black.

6. Fine-mesh forecasts — effects of revised analyses

It was noted in section 4 that the poor fine-mesh forecast from 0000 UTC on 7 November 1989 may have been at least partly due to deficiencies in the analysis. This forecast was therefore rerun from the corresponding coarse-mesh analysis which included bogus data designed to improve the MSLP and thickness fields in the vicinity of the wave. However, the net effect on the fine-mesh forecast was minimal, only resulting in very slight deepening of the MSLP trough, with still no hint of a closed low centre.

Further experiments were undertaken in which additional bogus data at the 250 mb height level were included in the assimilation with the aim of optimizing the analysis further. In particular, efforts were directed towards ensuring that the analysis properly reflected the strength of the jets and the sharpness of the upper trough. The best result was obtained by inserting winds alone, and the resultant 36-hour forecast is shown in Fig. 12. It can be seen that in this case the model managed to generate a closed centre of 1003 mb and also produced an improved rainfall forecast. However, the movement of the low was much too slow and its vigour still seriously underestimated.

The results of the reruns carried out to date must be judged disappointing. It has not been possible to demonstrate that the model solution was sensitive to any particular aspect of the initial conditions, unlike the Great Storm where subsequent inclusion of a group of late aircraft reports had a significant impact on the forecast (Lorenc *et al.* 1988).

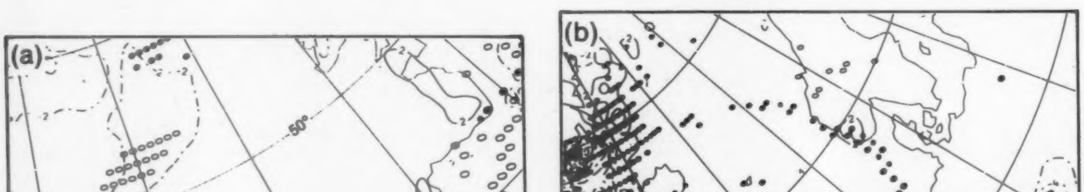

Figure 11. Fine-mesh vertical velocity field (open circles show areas $\geqq 6.2$ mb h^{-1} descending, solid circles show areas 6.2–12.5 mb h^{-1} ascending and asterisks show areas $\geqq 12.5$ mb h^{-1} ascending), and thermal advection field (dash-dot line in °C per 6 hrs). (a) Analysis for 0000 UTC on 7 November 1989, and (b) 24-hour forecast valid for 0000 UTC on 8 November 1989. X marks the position of the low centre.

7. Conclusions

This case-study demonstrates that even in this era of high-quality numerical guidance, the 'man on the bench' can still have an important role to play in improving forecasts. There is a danger that, because the model is usually so dependable, forecasters can be lulled into a false sense of security. It is obviously important to recognize those situations where the model may be significantly in error, especially when the deficiencies may result in a failure to predict severe weather.

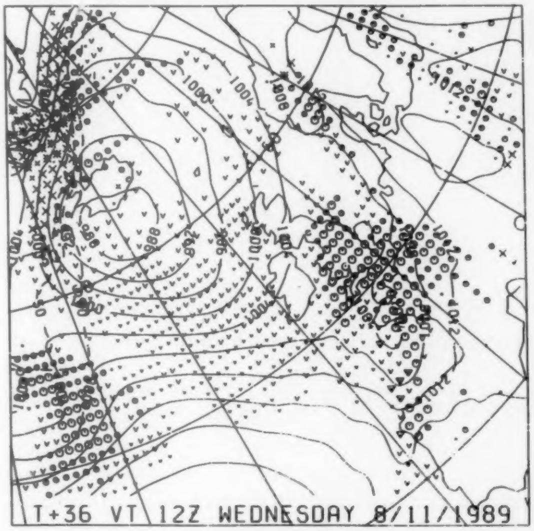

Figure 12. Best rerun fine-mesh forecast valid for 1200 UTC on 8 November 1989 the various symbols showing areas of precipitation.

Particular care is needed in situations involving confluent upper troughs. Rapid pressure rises behind the trough can quickly generate very strong winds to the rear of the associated MSLP low centre, even when pressure falls ahead of the system have been relatively modest. The primary responsibility for identifying such situations rests, of course, with CFO.

Recent experience during the notably stormy winter of 1989/90 (including the Burns' Day storm of 25 January 1990 (McCallum 1990)) shows that it is not unusual for there to be marked fluctuations in the quality of model guidance from run to run. Despite good earlier indications of major cyclonic development, the model occasionally lapses into a weak or non-developmental mode which can all too easily encourage a downgrading of previous warnings of severe weather. Although limitations in the initial data must play an important part in causing such oscillations, it is noteworthy that reruns of the fine-mesh model from 0000 UTC on 7 November 1989, incorporating additional bogus data to try and improve the analysis, have so far failed to produce a satisfactory forecast. Moreover, Fig. 13(a) shows that, although this run produced by far the worst guidance, the following three runs (based on data times of 0600 and 1200 UTC on 7 November and 0000 UTC on 8 November 1989) all displayed the same systematic error, namely underestimation of the deepening and, as a consequence, the amount of turning to the left. By comparison, errors in the forecast track and depth from successive CFO 24-hour forecasts (Fig. 13(b)) were generally much smaller.

To summarize, one needs to be very wary when the model suddenly reverses earlier indications of vigorous

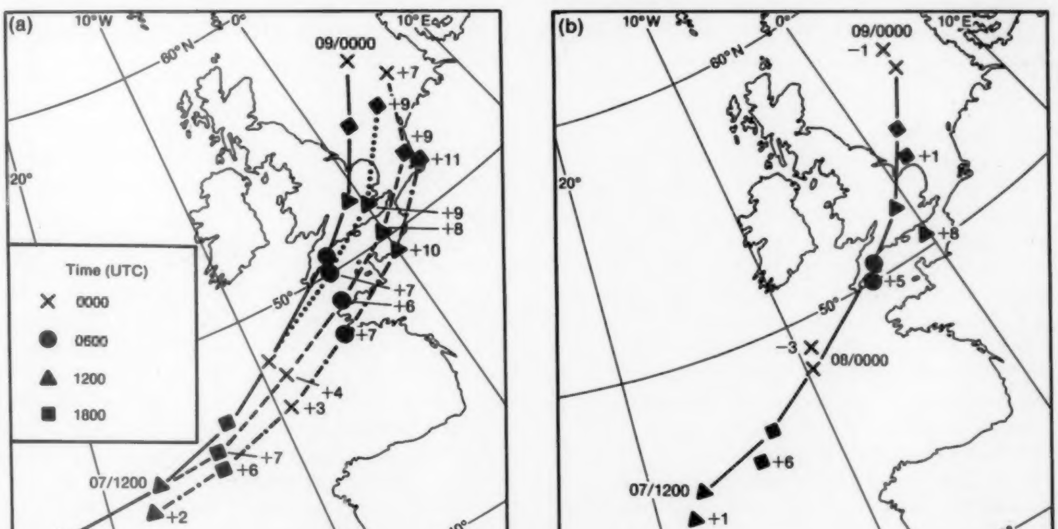

Figure 13. Errors in track and depth (mb) of the low centre from (a) fine-mesh forecasts, and (b) CFO 24-hour forecasts. In (a) the tracks shown are: actual track (continuous line), and fine-mesh runs from 0600 UTC on 7 November (dash-dot line), from 1200 UTC on 7 November (dashed line) and from 0000 UTC on 8 November (dotted line). In (b) the continuous line shows the actual track, and CFO 24-hour forecast with errors in central pressure (mb) alongside (time key as Fig. 13(a)).

cyclonic development. Experience has shown that the latest model guidance may not always be the best, especially when dealing with a complex low-pressure area involving two or more waves. Judgement of the most likely outcome must depend on careful consideration of the satellite imagery in conjunction with the thickness and upper-air patterns.

Acknowledgements

The author would like to thank O.M. Hammon (Forecasting Research Branch) for carrying out the reruns of the fine-mesh model, also M.V. Young (Nowcasting and Satellite Applications Branch) for his useful comments on the interpretation of the satellite imagery.

References

Gadd, A.J. and Morris, R.M., 1988: Guidance available at Bracknell for the storm of 15/16 October 1987, and the forecasters' conclusions at the time. *Meteorol Mag*, **117**, 110–117.

Lorenc, A.C., Bell, R.S., Davies, T. and Shutts, G.J., 1988: Numerical forecast studies of the October 1987 storm over southern England. *Meteorol Mag*, **117**, 118–130.

McCallum, E. 1990: The Burns' Day storm, 25 January 1990. *Weather*, **45**, 166–173.

Woodroffe, A., 1988: Summary of weather pattern developments of the storm of 15/16 October 1987. *Meteorol Mag*, **117**, 99–103.

Young, M.V., 1989: Liaison with the Central Forecasting Office regarding imagery interpretation for a cyclogenesis event: 20–21 October 1989. (Unpublished, copy available in National Meteorological Library, Bracknell.)

551.5(09):33:37:06(41–4)

The United Kingdom's contribution to the WMO Voluntary Co-operation Fellowship Programme

F.D. Reece

Meteorological Office College, Shinfield Park

Summary

The history of the World Meteorological Organization (WMO) Voluntary Co-operation Programme Fellowships fund is described, and the operation of the United Kingdom's contribution to it is summarized. The past performance of the fund is reviewed in the light of a recent survey conducted among recipient nations. The current state of the fund is described and plans for its future management are discussed.

1. Introduction

In the 1960s the Voluntary Assistance Programme (VAP) was created by the WMO in order to provide assistance to developing countries for them to fulfil their role in the implementation of the World Weather Watch plan. Under this programme, WMO members provided voluntary contributions of equipment and services in kind, or financial contributions.

Under WMO these resources were distributed to WMO member states who requested assistance. This assistance could take many forms ranging from the supply of equipment for synoptic surface or upper-air observing stations through telecommunications equipment for the Global Telecommunication System to the financial support of students on long- and short-term fellowships for formal or on-the-job training in meteorology abroad. Universities and Regional Meteorological Training Centres (RMTCs) would be the main providers of such formal training while on-the-job training would be achieved through the attachment of trainees from the Third World countries to more highly developed National Meteorological Services for suitable periods.

In the first year of the VAP the value of the assistance provided through WMO was worth just under US$1.4 million world-wide and it was the stated aim of the Executive Committee of WMO that ultimately all members of WMO would eventually find it possible to make contributions, however small, to the VAP (World Meteorological Organization 1971). In 1979 the VAP was renamed the Voluntary Co-operation Programme (VCP). By 1986 the value of VCP contributions world-wide had risen to US$5.4 million.

The Meteorological Office has consistently given support to this programme through two separate funds. The UK/VCP (Equipment and Services) fund administered by the Meteorological Office's International and Planning Branch is the largest of these two funds whilst the UK/VCP (Fellowships) fund is administered by the

Meteorological Office College. It is this latter fund which forms the subject of this article which is based on a presentation given to the Commonwealth Meteorologists Conference in June 1989 (Shaw, personal communication).

2. UK/VCP Fellowships

The UK/VCP Fellowship Programme has now been operating for about 20 years and current expenditure is running at £176 000 per annum. This allows around 15 new Fellowships to be granted in any one financial year. In addition, a flexible approach to the management of the UK/VCP (Equipment and Services) fund makes it possible to provide a few additional Fellowships in the technical training area. To date, all Fellowships have been allocated within the United Kingdom. The Meteorological Office sees its commitment to the VCP Fellowship Programme as a contribution towards the World Weather Watch in particular. More than £1 million has been spent in the last 10 years and clearly such expenditure has to be properly managed. To this end the Meteorological Office carried out a major survey of the VCP Fellowship Programme at the end of 1987 (Mills, personal communication).

3. The 1987 survey

Before the survey there had been little indication as to whether or not any Fellowships granted had proved successful after the return of the Fellows concerned to their home countries. The survey examined 123 Fellowships granted since 1970 and spread among 53 different countries. Questionnaires were sent to the WMO Permanent Representatives of the National Meteorological Services of 110 of the 123 Fellows.

Preparation of the survey led to a better perspective of exactly how the allocation of Fellowships had been made according to the type of training provided. Of the 110 Fellowships considered by the survey, 67 were awarded for places on Meteorological Office College courses. Of these, 43 were for technical training courses and the other 24 were for a variety of meteorological courses. Of the remaining 43 Fellowships, 39 had been awarded for first degree or post-graduate courses at the University of Reading and the other four for a miscellany of other UK-based courses. The degree course Fellowships are more demanding of funds than those for other courses because of their longer duration and so the Fellowships awarded for degree courses are numerically fewer than those awarded for other courses.

The distribution of funds between long- and short-term Fellowships is judged to have been reasonably well balanced to date. It could be argued that a wider distribution of Fellowships among UK training institutions would be desirable, but in practice Fellowships at institutions other than those in the Reading area are not often sought.

The survey questionnaire sought to establish whether the Fellow concerned was still in service and, if so, what post he or she currently held. It also sought information on any subsequent VCP awards and invited comment from the National Meteorological Service concerned as to the usefulness of the training provided under the Fellowships. Sixty-eight per cent of the questionnaires were returned (76 out of 110). It was gratifying to find that the majority of Fellows who have gained benefit from the training they received under VCP have continued to be employed by their National Meteorological Services.

Leaving aside the unavoidable losses due to retirement or death, only 11 of the 76 Fellows (15%) have been lost to meteorology. This is an encouragingly low wastage rate; it provides the best indication of success which we have for the Fellowship Programme.

The invitation for general comments on the questionnaire yielded no adverse criticisms. However, it should be noted that 18 of the 53 countries who had been granted Fellowships failed to respond to the questionnaire and so the scope of the survey was limited and the results must be treated with caution.

The results of the survey nevertheless indicate that the great majority of Fellows benefit from the Fellowships and return to their National Meteorological Services to give lasting commitments to meteorology. The Meteorological Office has been encouraged by the survey to persevere with its programme of VCP Fellowships.

4. Selection policy

In selecting Fellows for sponsorship the potential for each Fellowship to make a positive contribution to the World Weather Watch remains to the fore. Account must also be taken of the potential value of the training proposed to the National Meteorological Service seeking the Fellowship and the suitability of the candidate.

Management of the VCP fund is tied to the financial year which begins on 1 April. The total monies available, less those committed for ongoing Fellowships, are known some months before this. Early in the calendar year applications for UK/VCP Fellowships received via the WMO Education and Training Department are considered by a Selection Board.

In reaching its decisions the Board seeks the advice of the Head of the International and Planning Branch of the Meteorological Office to ensure that a proper international perspective is maintained and that the programme of Fellowships dovetails with that of the VCP (Equipment and Services) fund. Discussions with the University of Reading (see section 5) may also take place at this stage and there is also some involvement of the Fellowship Division of the WMO Training and Education Department. Soon after the board has completed its deliberations a preliminary proposal for the coming financial year is prepared and a list of recommended fellowships is presented to the Chief Executive of the Meteorological Office for his approval.

This annual review normally commits the bulk of the available funds up to the end of the coming financial

year (i.e. up to 15 months ahead). Later in the calendar year there is limited scope for the reallocation of funds from Fellowships which for various reasons are not taken up, or for considering applications received after the review.

5. Current arrangements

The United Kingdom programme is in a healthy state. Fig. 1 shows the funding levels for the financial years 1985/86 to 1989/90 and the planned levels for the future. The figures are not adjusted for inflation but it is clear that a planned growth of funding in real terms is now taking place.

In spite of the welcome increase in money actually spent over recent years Fig. 1 shows that for each of the first four financial years the monies available have not been fully spent. There are a number of reasons for this. For instance in the financial year 1987/88 the underspend of £40 000 was largely brought about by the late cancellation of our College-based Basic Electronics course due to an insufficient number of students. This in turn was due to a reduction in expected Fellowships

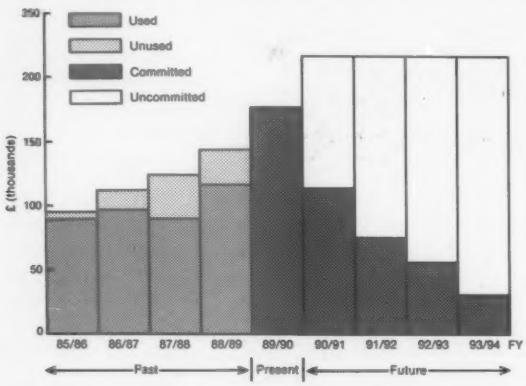

Figure 1. Actual past, expected current and planned future expenditure compared to the total United Kingdom VCP (Fellowship) funds available in each financial year.

from other funding sources, for example the United Nations Development Programme. In addition, £10 000 had been reserved in recent years as a part contribution to a distance learning project which failed to come to fruition. Another source of underspend has been that some Fellowships offered have not been taken up. If notification of this is not received soon enough it is impossible to allocate the funds released to other fellowships before the start of the academic year.

This failure to fully utilize the available funds has led to a reconsideration of the way in which the fund is managed. In 1989, in addition to the major review of applications early in the calendar year, a second review was taken some weeks before the start of the academic year. This second review has enabled the monies available in financial year 1989/90 to be used to much better effect and it is intended to continue this policy in future years.

The current costs of Fellowships most commonly sought are given in Table I. The first seven courses listed are based at the Meteorological Office College and the last two are based at the University of Reading. The B.Sc. course at the University of Reading is now normally treated as a 4-year Fellowship for overseas students and includes a preparatory year which precedes the formal B.Sc. course. The cost of such a Fellowship (£43 000) is very high, quite apart from the loss of the student to his Meteorological Service for 4 years. This high investment in terms of time and money underlines the need for very careful selection of Fellows for this and all other courses. The courses based at the Meteorological Office College are training, as distinct from educational, courses and are primarily intended for UK Meteorological Office staff. However, if there are vacancies on appropriate courses these are offered to suitable overseas candidates and a proportion of these are VCP Fellows.

On the other hand the Meteorological Engineers course (MEC) and the Instrument Maintenance (non-electronics) course (IMC) are both designed specifically

Table I. Sample Fellowship costs (pounds sterling) for different Meteorological Office College and University of Reading courses

Course	Duration	Course fees	Fixed* costs	Variable* costs	Total cost
Scientific Officers	21 weeks	7730	919	1278	9927
Applied Meteorology	22 weeks	8302	919	670	9891
Initial Forecasting	18 weeks	6789	919	550	8258
Advanced Forecasting	7 weeks	3138	858	235	4231
Extension Forecasting	4 weeks	1693	858	140	2691
Meteorological Engineers	8 months	14000	919	1155	16074
Instrument Maintenance	16 weeks	4000	1039	1534	6573
B.Sc. (Meteorology)	4 years	22800	1359	18528	42687
M.Sc. (Meteorology)	2 years	11400	1317	9264	21981

* Fixed costs include arrival and departure allowances, books, equipment and clothing allowances plus British Council handling charges. Variable costs include living expenses and health insurance.

for overseas services. Both of these courses attract support not only from VCP but also from other WMO funding agencies, the United Nations Development Programme and the British Council.

The 4-month long IMC provides training in the maintenance, repair and calibration of conventional Meteorological Instruments. It is a well established course having run for several years now.

The MEC lasts 8 months and provides a thorough grounding in the theoretical knowledge and practical skills required to assemble, install, maintain and repair a wide range of operational electrical and electronic equipment (see Fig. 2). The course has replaced the 18-month Basic Electronics course, much of which was based at Reading College of Technology. The MEC is an intensive residential course with evening sessions and on-the-job outstation attachments to consolidate the students practical skills. Successful completion of the MEC will be recognized by the award of a Diploma in Meteorological Engineering (Dip. Met. Eng.). The Business and Technician Education Council (BTEC) believe that the MEC could provide a sound route into higher education and that Dip. Met. Eng. should be considered alongside BTEC National Certificates or Diplomas and General Certificate of Education (GCE) A-level certificates for entry into BTEC Higher National courses in the engineering field.

The first MEC attended by 7 students ended in May 1989; the second began in October 1989 and comprises 9 students. Of these 16 overseas students from 13 different countries, 7 have been funded either wholly or partly through the UK/VCP (Fellowships) fund, 6 through the UK/VCP (Equipment and Services) fund and 3 through other funding agencies.

6. The future

The WMO Panel of Experts on Education and Training in Cairo in 1989 (World Meteorological Organization 1989) highlighted three issues relevant to the Voluntary Co-operation Programme Fellowship scheme.

The first of these issues was the increasing demand for long-term Fellowships (i.e. those longer than one year in duration). In the United Kingdom these Fellowships are nearly always based at universities simply because courses available at the Meteorological Office College are invariably less than a year long. This reflects the training policy of the Meteorological Office for relatively short, intensive training courses. From this parochial viewpoint it is difficult to justify an increased emphasis on long-term VCP Fellowships at the expense of short-term ones, even though the increased demand for long-term Fellowships is real.

The second issue raised by the Panel of Experts concerned the benefits of arranging group, rather than individual, training where possible. This already occurs to some extent in the United Kingdom with the IMC and MEC at the Meteorological Office College. Another

Figure 2. Members of the first Meteorological Engineering course under instruction at the Meteorological Office College, Shinfield Park.

form of group training programme is being developed within the Meteorological Office which involves training in the use and interpretation of Numerical Weather Prediction (NWP) products from the Bracknell Global Forecast Model the output from which is becoming increasingly available for use by forecasters in the developing countries.

Preliminary discussions have taken place on the possible establishment of a programme of Fellowships in which the student would undertake some formal training in NWP appreciation, partly based at the Meteorological Office College. A period of on-the-job training in the Central Forecasting Office would then follow using the Office's NWP products. The aim of these training Fellowships would be to thoroughly familiarize students with these NWP products. On return home they could then use and develop these operationally disseminated products to the special requirements of their own National Meteorological Service.

This type of training is particularly appropriate for those who will be working at the African Centre for Meteorological Applications for Development project and some VCP funds have been set aside to support this undertaking. The logistics of the programme have yet to be decided but it is hoped that training of small groups of Fellows can be arranged. This should be very much in keeping with the Panel's recommendation. It is interesting to note that during 1989 an overseas student successfully completed a 4-month Fellowship of this type. In addition to short-term Fellowships of this sort within the Meteorological Office it may also be appropriate to provide some long-term Fellowships at United Kingdom universities in support of the same programme.

The third recommendation made by the Panel was that consideration should be given to the use of VCP funds in support of Fellowships at the WMO Regional Meteorological Training Centres (RMTCs). There are currently 17 of these RMTCs and the great majority are in the developing countries. Nine of them are in Africa, the Middle East and the Indian Ocean. Of the remaining eight, five are in the Caribbean and Central and South America, with one each in India, the Philippines and Europe.

As a result of the Panel's recommendation a review of UK/VCP Fellowship funding policy was conducted early in 1989 and approval was given for up to 10 per cent of the fund to be spent overseas in support of the RMTCs. The potential benefits of such a policy are numerous. For instance, a course of particular relevance to a WMO Region could be supported at an RMTC in the Region by sponsorship of VCP Fellows for the course in question. Fellowships at the RMTCs promise to be more cost-effective than those taking place in the United Kingdom because there will be less travel involved and so costs are likely to be lower. In addition, although courses at the RMTCs tend to be long compared to the shorter intensive training courses held at Shinfield Park, the tuition fees and living expenses are much lower in the developing countries. We therefore have the exciting prospect of being able to provide more UK/VCP Fellowships per year than was possible previously.

The practicalities of implementing this policy in a sensible, cost-effective way were addressed in talks at WMO in Geneva in February 1990 when ways and means of achieving this end were explored.

A small portion of the fund for the 1989/90 financial year has already been used for a training project, in support of the Nairobi RMTC early in 1990. This project provided training in the presentation of television weather forecasts for a number of forecasters from several different African countries. The training project was undertaken by one of our television weathermen and a BBC producer in conjunction with the staff of the RMTC. It is hoped that this pilot project will be the standard-bearer of a continuing programme of helping the RMTCs to improve and extend their capability to provide high-quality training for meteorologists within their own Region.

7. Conclusion

The UK/VCP (Fellowship) fund is seen as a significant component of the Voluntary Co-operation Programme world-wide. Results of the 1987 survey confirm that the training provided through the programme has been a sound investment and has contributed to the development of the Meteorological Services of the recipient nations and hence to the World Weather Watch.

The fund is currently being utilized to the full and the size of the fund is being increased in real terms to take account of increased training needs. These needs are commensurate with the spread of modern technology, the improving communication links with the National Meteorological Services of the developing countries and the needs of their staff to acquire new skills.

In order to make best use of the monies available, more cost-effective ways of optimizing the provision of training Fellowships under the fund are being explored. This will require continuing close co-operation with the Education and Training Department of the WMO over the years ahead.

References

World Meteorological Organization, 1971: WMO helps the developing countries. Geneva, WMO, No.307.

—, 1989: Report of the thirteenth session of the Executive Council Panel of Experts on Education and Training. Geneva, WMO.

551.506.1(41-4)

The summer of 1989 in the United Kingdom

G.P. Northcott
Meteorological Office, Bracknell

Summary

The summer of 1989 was warm, dry and sunny in most places, with record sunshine in many areas, particularly in the south.

1. The summer as a whole

Mean temperatures over the three months from June to August 1989 were above normal nearly everywhere and ranged from 0.2 °C below normal in a few parts of western Scotland to 2.2 °C above normal in south-west Cornwall. Seasonal rainfall amounts were about average in northern Scotland and above average in western Scotland. Elsewhere the summer was rather dry or in some places very dry, although locally there were large amounts of rainfall, mainly as the result of thundery activity during August. Rainfall amounts ranged from nearly 150% in the Western Isles of Scotland to less than 40% over the Channel Islands and parts of the south coast from Plymouth, Devon to Bognor Regis, West Sussex. The relative lack of rainfall during the summer was reflected in soil moisture deficits of more than 40 mm above average in many parts of central southern and south-west England at the end of June, spreading to eastern areas by the end of July. By the end of August soil moisture deficits were between 30 and 40 mm above average over much of England and Wales, notable exceptions being the Lake District and Snowdonia which were near field capacity. Sunshine amounts were near or slightly above average over Scotland, whilst most of England and Wales had a sunny summer; amounts exceeded 150% of normal in the Midlands, but were as low as 88% at Benbecula, Western Isles.

Information about temperature, rainfall and sunshine during the period from June to August 1989 is given in Fig. 1 and Table I.

2. The individual months

June. Mean monthly temperatures were generally just above normal in England, Wales and Northern Ireland, but slightly below normal in Scotland, ranging from about 1 °C above normal in places in southern England to nearly 1 °C below normal in the Western Isles. Halesowen, West Midlands had the highest June maximum since 1976 with 29.7 °C on the 20th which was the second warmest June day there since at least 1956; in contrast the 2nd was the coldest June night since 1962, with a minimum temperature of 0.1 °C.

Monthly rainfall amounts were generally below or near normal; however, parts of southern Scotland and northern and eastern England had higher than average values. The most rain fell at Blackpool, Lancashire with nearly twice the normal rainfall, compared with Exeter, Devon where only a third of the normal rain fell.

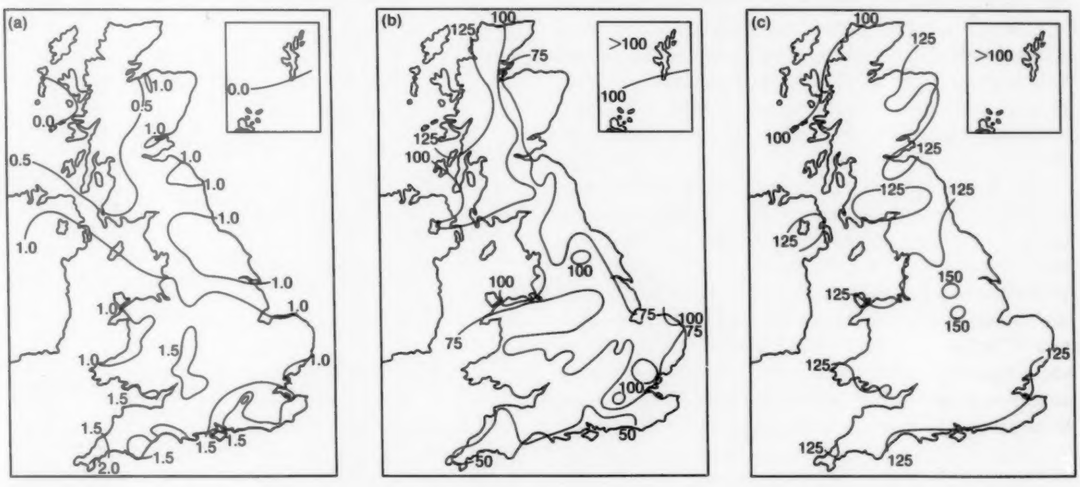

Figure 1. Values of (a) mean temperature difference (°C), (b) rainfall percentage and (c) sunshine percentage for summer, 1989 (June–August) relative to 1951–80 averages.

Table I. District values for the period June–August 1989, relative to 1951–80 averages

District	Mean temperature (°C)	Rain-days	Rainfall	Sunshine
	Difference from average		Percentage of average	
Northern Scotland	+0.4	+1	100	106
Eastern Scotland	+0.9	−3	71	120
Eastern and north-east England	+1.1	−4	75	137
East Anglia	+1.2	−2	84	137
Midland counties	+1.3	−4	73	140
South-east and central southern England	+1.6	−3	59	133
Western Scotland	+0.5	0	103	123
North-west England and North Wales	+0.9	−2	77	131
South-west England and South Wales	+1.4	−4	64	132
Northern Ireland	+1.1	−1	87	125
Scotland	+0.6	−1	95	116
England and Wales	+1.3	−3	71	135

Highest maximum: 34.2 °C in south-east and central southern England in July.
Lowest minimum: −2.4 °C in western Scotland in June.

Monthly sunshine totals were above normal nearly everywhere, although in parts of the Scottish Highlands and the Western Isles it was rather dull, and amounts varied from as much as 139% at Leeming, North Yorkshire to 89% at Stornoway, Western Isles. At Halesowen, June was the sunniest since 1976 with 258 hours of bright sunshine. Wingerworth, Derbyshire reported the sunniest June in 20 years of record at the station, 53 hours higher than the mean for the month.

For the first 8 days of the month the weather was cool and showery in all parts of the United Kingdom, with thundery outbreaks occurring on most days, mainly in southern areas. On the 5th and 6th, thundery showers became widespread and prolonged in some areas, particularly in a belt from Merseyside to south-east England; in the Gillingham area of Kent hailstones lay to a depth of several centimetres, bringing traffic to a halt. The Surrey Fire Brigade were called out to floods, and a mother and her young child were taken to hospital after the roof of their house collapsed when it was struck by lightning. Also on the 6th a tornado was reported near Brightlingsea, Essex. The weather was warmer and predominantly dry from the 9th to the 12th in all areas, while heavy, thundery rain came to much of northern England and north-west Wales on the 13th, with scattered outbreaks of rain in other western areas of England and Wales. All areas again became dry on the 14th. Skies were cloud-free nearly everywhere in Scotland from the 17th to the 20th. Apart from some showers and thunderstorms overnight on the 21st/22nd in parts of East Anglia and Kent, it remained mainly dry until the 24th when rain moved southwards from Scotland replacing dry weather which had in some places lasted 18 days; rain was particularly heavy and prolonged over North Wales and northern England. Elsewhere many places had showers, and some of those in eastern England were accompanied by thunderstorms.

July. Mean monthly temperatures were above normal everywhere, ranging from 0.3 °C above normal in Shetland to more than 3 °C above normal at Plymouth, Devon. Northwood, Greater London reported the 22nd as the hottest day of any month since July 1983. Hampstead, Greater London reported the warmest July since 1983 and its highest minimum of 20.1 °C was second only to that of 1949 (20.4 °C) in a record going back to 1909. The mean maximum of 21.7 °C at Turnhouse (Edinburgh Airport), Lothian Region was the highest since the record began in 1948. The minimum temperature of 3.5 °C at Glasgow Airport, Strathclyde Region was the lowest at the station since 1971.

Monthly rainfall totals were generally below normal apart from some parts of south-east England, Shetland and Northern Ireland, where rainfall amounts were above normal, ranging from 13% at Plymouth, Devon to 162% at Stansted, Essex. The 29th marked the end of a long spell of dry weather in many places. The south coast around Southampton still escaped measurable rainfall, some places having had no measurable rain since the 8th. The monthly total of 9 mm at Edinburgh, Royal Observatory was the lowest ever for July at the station, although there are documented values of 9 mm in July 1868 and 4 mm in July 1825 at other sites in Edinburgh.

Monthly sunshine amounts were above normal everywhere except part of the Western Isles where amounts were just below normal, Benbecula measuring only 94%, whereas the greatest percentage of average sunshine was 192 at Armagh in Northern Ireland. Many places had the sunniest July for many years; Eskdalemuir, Dumfries and Galloway had the sunniest July since records began there in 1910 and Bude, Cornwall the sunniest since records began there in 1913. Wingerworth, Derbyshire had the sunniest July since 1976. Northern Ireland and parts of central and southern Scotland had

the sunniest July since 1955. The 3rd was the sunniest July day this century at Sheffield (Weston Park), South Yorkshire.

After some rain on the 1st it became hot and fine, with northern areas remaining almost completely dry until the onset of rather changeable weather around the 9th and 10th. However, thundery outbreaks in many parts overnight on the 5th/6th, and on the 7th and 8th produced widespread heavy rain. It became mainly dry and hot again between the 12th and the 26th, although thundery outbreaks gave heavy rain in a few places until more widespread rain came to Scotland on the 25th. The rest of the month was rather unsettled in Scotland, and a shorter unsettled spell affected England and Wales (apart from a few south-coastal areas). However, in many places the weather continued mainly dry. There were isolated thunderstorms on the 23rd and 24th. Thunderstorms developed along the Thames Valley and over Northern Ireland and western Scotland on the 25th, spreading later to some parts of eastern Scotland. Further outbreaks occurred over Norfolk on the 29th, and in parts of northern England, the Midlands and East Anglia on the 30th. On the 6th hailstones of 30 mm diameter were reported near Basingstoke, Hampshire and of 15 mm diameter at Sedgeley, West Midlands.

August. Mean monthly temperatures were above normal everywhere in the United Kingdom except the far north of Scotland and ranged from just below normal at Lerwick, Shetland to nearly 2 °C above normal at Gatwick, West Sussex.

Monthly rainfall amounts were below normal everywhere except for parts of North Wales, Cumbria and western Scotland and ranged from 264% of normal at Tiree, Strathclyde Region to as little as 16% of normal at Guernsey Airport, Channel Islands. A fall of 21.2 mm of rain was recorded on the 25th at Aldergrove, Co. Antrim between 1430 and 1445; such a fall in 15 minutes has a return period of about 150 years. Some places in the vicinity of Southampton and the Isle of Wight had no measurable rain from 8 July until the end of August.

Monthly sunshine amounts were above normal everywhere except Northern Ireland and western Scotland and ranged from 73% of average at Tiree to 159% of average at Birmingham, West Midlands and Wyton, Cambridgeshire. Sheffield (Weston Park), South Yorkshire had the sunniest August in a record going back to 1898, beating the previous record set in 1947. In the West Midlands, Coventry had the sunniest August since 1947 and Halesowen the sunniest since 1976. Oxford reported another remarkably sunny month, the second sunniest August in 110 years of records. It was generally the third sunniest August in England and Wales this century after 1976 and 1947.

Very little rain fell during the first week except in parts of Scotland. From the 9th to the 17th it was rather unsettled with some rain, heavy in places. On the 14th a tornado struck the Butlins holiday camp at Pwllheli, on the Lleyn Peninsula in North Wales, removing the roofs of 150 timber chalets and causing considerable damage to other buildings; costs were estimated at more than £2 million. Much of England and Wales remained dry between the 18th and the 23rd inclusive, whilst Scotland and the north of England had further rain. Rain moved southwards across England late on the 24th and the 25th and was persistent in places. Very heavy thundery rain caused flooding at Aldergrove, Co. Antrim on the 25th. Showers were locally heavy in eastern England on the 26th, becoming confined mostly to eastern coasts on the 27th. After a dry day in most places on the 28th, it stayed mainly dry up to the end of the month in the south-east, but became unsettled in the west.

Notes and news

Meteorological Office attains Agency status

As announced in Notes and news in the *Meteorological Magazine*, December 1989, the Meteorological Office has recently become an Executive Agency within the Ministry of Defence. The change in status took place on 1 April 1990 and the occasion was marked by a ceremony at Bracknell on the following day, attended by many representatives of Government, customers, local civic groups and the media. During the ceremony Dr John Houghton, the Chief Executive, was formally handed a copy of the Framework Document, which sets out the rules by which the Agency is to be run, by Mr Michael Neubert MP who is the Government Minister responsible for the Office's affairs.

Dr Houghton spoke of the further opportunities that Agency status would bring to the Office in terms of greater freedom to manage itself in order to bring a better service to its customers.

The structure of the Office has undergone considerable changes for the better use of its resources to meet the challenges of the future. It is to be run by a Management Board lead by the Chief Executive with four further members:

Director of Operations	Dr Peter Ryder
Director of Research	Dr Keith Browning
Director of Commercial Services	Mr Bernard Herdan
Director of Finance and Administration	Mr Michael Bowack

Reporting to the Board are seven Deputy Directors responsible for Central Forecasting, Defence Services, Observations, Communications and Computing, and research into Atmospheric Processes, Short-Range Forecasting, and Extended-Range Forecasting and Climate.

Satellite photograph — 27 May 1990 at 2100 UTC

The infra-red image shown in Fig. 1 was taken by the geostationary satellite, GOES, and was received on facsimile machine at the Meteorological Office at Bracknell via landline from the USA.

In the USA, infra-red images are routinely displayed with enhancement curves. Essentially, grey scales are repeated so as to draw attention to particular ranges of cloud-top temperature. This picture was received with the 'MB' curve, where all cloud colder than −32 °C is highlighted. The major cold-cloud regions are labelled M and C, and show a mesoscale convective system just north of the Gulf of Mexico (coldest cloud tops below −70 °C) and cloud associated with a mid-latitude depression (Fig. 2) over the Atlantic Ocean.

Elsewhere, a band of convection with less-cold tops (S) extends from western Florida around the Gulf coast probably marking a sea-breeze front, and a large cloud-free zone covers the Great Lakes.

G.A.Monk

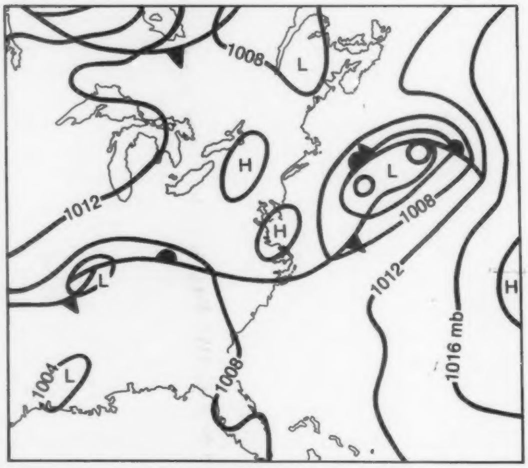

Figure 2. Synoptic analysis at 0000 UTC on 28 May 1990 (polar stereographic projection).

Figure 1. GOES infra-red 'space view' image at 2100 UTC on 27 May 1990 with 'MB' enhancement curve. Repeat grey scales represent the following temperature ranges: medium grey −32 to −41 °C, white −41 to −52 °C, dark grey −52 to −58 °C, black −58 to −62 °C, then repeating black to white −62 to −80 °C.

GUIDE TO AUTHORS

Content

Articles on all aspects of meteorology are welcomed, particularly those which describe results of research in applied meteorology or the development of practical forecasting techniques.

Preparation and submission of articles

Articles, which must be in English, should be typed, double-spaced with wide margins, on one side only of A4-size paper. Tables, references and figure captions should be typed separately. Spelling should conform to the preferred spelling in the *Concise Oxford Dictionary* (latest edition). Articles prepared on floppy disk (Compucorp or IBM-compatible) can be labour-saving, but only a print-out should be submitted in the first instance.

References should be made using the Harvard system (author/date) and full details should be given at the end of the text. If a document is unpublished, details must be given of the library where it may be seen. Documents which are not available to enquirers must not be referred to, except by 'personal communication'.

Tables should be numbered consecutively using roman numerals and provided with headings.

Mathematical notation should be written with extreme care. Particular care should be taken to differentiate between Greek letters and Roman letters for which they could be mistaken. Double subscripts and superscripts should be avoided, as they are difficult to typeset and read. Notation should be kept as simple as possible. Guidance is given in BS 1991: Part 1: 1976, and *Quantities, Units and Symbols* published by the Royal Society. SI units, or units approved by the World Meteorological Organization, should be used.

Articles for publication and all other communications for the Editor should be addressed to: The Chief Executive, Meteorological Office, London Road, Bracknell, Berkshire RG12 2SZ and marked 'For Meteorological Magazine'.

Illustrations

Diagrams must be drawn clearly, preferably in ink, and should not contain any unnecessary of irrelevant details. Explanatory text should not appear on the diagram itself but in the caption. Captions should be typed on a separate sheet of paper and should, as far as possible, explain the meanings of the diagrams without the reader having to refer to the text. The sequential numbering should correspond with the sequential referrals in the text.

Sharp monochrome photographs on glossy paper are preferred; colour prints are acceptable but the use of colour is at the Editor's discretion.

Copyright

Authors should identify the holder of the copyright for their work when they first submit contributions.

Free copies

Three free copies of the magazine (one for a book review) are provided for authors of articles published in it. Separate offprints for each article are not provided.

July 1990

Editor: F.E. Underdown
Vol. 119
No. 1416

Contents

Contributions: It is requested that all communications to the Editor and books for review be addressed to the Chief Executive, Meteorological Office, London Road, Bracknell, Berkshire RG12 2SZ, and marked 'For *Meteorological Magazine*'. Contributors are asked to comply with the guidelines given in the *Guide to authors* which appears on the inside back cover. The responsibility for facts and opinions expressed in the signed articles and letters published in *Meteorological Magazine* rests with their respective authors.

Subscriptions: Annual subscription £30.00 including postage; individual copies £2.70 including postage. Applications for postal subscriptions should be made to HMSO, PO Box 276, London SW8 5DT; subscription enquiries 071−873 8499.

Back numbers: Full-size reprints of Vols 1−75 (1866−1940) are available from Johnson Reprint Co. Ltd, 24−28 Oval Road, London NW1 7DX. Complete volumes of *Meteorological Magazine* commencing with volume 54 are available on microfilm from University Microfilms International, 18 Bedford Row, London WC1R 4EJ. Information on microfiche issues is available from Kraus Microfiche, Rte 100, Milwood, NY 10546, USA.

ISBN 0 11 728667 2

ISSN 0026−1149

ISBN 0-11-728667-2

9 780117 286672